



THE ANALYST.

JANUARY, 1901.

PROCEEDINGS OF THE SOCIETY OF PUBLIC ANALYSTS.

THE monthly meeting of the Society was held on Wednesday evening, December 5, in the Chemical Society's Rooms, Burlington House. The President (Mr. W. W. Fisher, M.A.), occupied the chair.

The minutes of the previous meeting were read and confirmed.

Certificates of proposal for election to membership in favour of Messrs. Percy Henry Carpenter and Samuel Russell Trotman, M.A., were read for the second time; and certificates in favour of Messrs. A. Leonard H. Garside, Torbay College, Torquay, Analytical Chemist, Lecturer on Chemistry at the Vivian Institute, Torquay; Robert George Grimwood, F.I.C., 17, Dagmar Road, Stroud Green, London, N., chief assistant to Mr. W. J. Dibdin, and Gas Examiner to the London County Council; John Charles Umney, 48, Southwark Street, London, S.E.; and H. Rowley, 277, St. George's Terrace, Perth, West Australia, Public Analyst for Perth and Fremantle, were read for the first time.

Mr. John Stewart Remington was elected a member of the Society.

Dr. Lewkowitsch and Mr. L. Kidgell Boseley were appointed to act as auditors of the Society's accounts for the year 1900.

The following papers were read: "The Examination of Extract of Malt," by Walter J. Sykes, M.D., and C. A. Mitchell, B.A.; "Note on the Estimation of Glycerine," and "The Examination of Varnish Resins," by J. Lewkowitsch, Ph.D.; "Note on the Occurrence of Barium in the Spring Water of Boston Spa," by Percy A. E. Richards; and "On the Analysis of Samarskite," by Arthur G. Levy.

A discussion, opened by Mr. Alfred C. Chapman, took place on the methods of testing for the presence of arsenic in beer and brewing materials.*

Some condensers of special patterns were shown by Mr. C. T. Tyrer.

* Mr. Chapman has, since the meeting, elaborated his remarks; they will be found on p. 8 of this number.

THE DETERMINATION OF THE AVAILABLE EXTRACT OF MALT.

BY LAWRENCE BRIANT.

(Read at the Meeting, November 7, 1900.)

THE determination of the available extract of malt is one in which there is room for considerable divergence of result. The operation is a very different one to the estimation of an acid or a base, for it is an endeavour in the laboratory to ascertain the amount of extract which is obtainable by a brewer in his actual brewing operations, the amount being dependent upon the specific gravity and quantity of saccharine wort obtainable from a known quantity of malt during the mashing and sparging operation in the brewery. My object in bringing this matter before you to-night is to point out the discrepancies which at present exist between determinations by different methods, and to suggest a method which is at once easy of performance and gives accurate results. Under the present condition of things, it is not an uncommon thing to find a difference of 2, 3, or even 5, pounds per quarter in the results given in different analyses. Such a difference would be a very serious matter to the brewer. Taking, for instance, a variation of 5 pounds per quarter (and this I have actually known to occur), and assuming that the brewer mashed 50 quarters of the malt per day, the difference in yield of beer per week of five days' working, represented by the divergence in the analysts' results, is no less than $62\frac{1}{2}$ barrels of a 20 lb. beer. It is natural that brewers may think these discrepancies are proof of very careless work, yet the fact is that they are really due to the varying methods adopted in laboratories.

In attempting to estimate the extract yielded by a malt, the obvious method seems to be to imitate as closely as practicable the actual operations as carried out in a brewery. The brewer mixes his ground malt with water in about the proportion of 2 barrels of water to 1 quarter of malt—that is, 720 parts of water to 336 parts of malt. He allows this mixture to stand at a temperature depending upon the character of the malt and the class of beer which he is producing, but which lies between 145 and 155. At the expiration of a given time—generally two hours—saccharification being complete—he draws off the extract and washes out that which remains in the “goods.” But this “sparging” operation does not merely consist of washing. The brewer sparges with water at a temperature considerably more elevated than that of his mash. As a consequence, the heat of the mash slowly rises, and starch, which during the malting operation has been imperfectly modified, gradually comes into solution, and the amount so dissolved will depend upon the original character of the malt, upon the temperature of the sparging water and the amount of the sparge. We have therefore a varying set of conditions which it is not easy to precisely imitate in the laboratory, and the extract yielded by a malt will depend a great deal upon these factors. The following results show this to be the case as regards temperature of stand of mash :

Mixture-heat.	Extract per 336 pounds.
140° F.	90.3 pounds.
145° F.	91.2 "
150° F.	90.1 "
155° F.	88.9 "
145° F. (raised to 150° by underlet in 20 minutes)	92.3 "

The extract will also, as above mentioned, vary with the temperature of sparging water. This is shown by the following figures :

Mixture-heat.	Sparge-heat.	Extract per 336 pounds.
149° F.	160° F.	91.3 pounds.
149° F.	175° F.	93.4 "
149° F.	{ $\frac{1}{3}$ rd 185° F. $\frac{1}{3}$ rd 175° F. $\frac{1}{3}$ rd 165° F.}	95.7 "

So that we see, by different temperatures of sparge, the extract may be affected to the extent of $4\frac{1}{2}$ pounds per quarter.

Yet another condition influences the result, namely, the fineness of grinding. There is, unfortunately, no standard of grinding adopted by chemists, yet the degree of fineness much influences the result. This is seen in the following figures :

	Extract per 336 pounds.
Very coarse grinding 	92.0 pounds.
Coarse " 	94.4 "
Fine " 	95.7 "
Crushed in mortar 	94.7 "

It is quite evident that, as precise temperature of mixture heat—sparge heat and grinding all exert a considerable influence upon the extract—it is very difficult to get regularity of working upon these lines.

For many years the author was in the habit of determining the extract of malt in a miniature mash conducted on precisely the lines obtaining in breweries, though the influence of bulk was of course absent; but it was found that very slight alterations in temperature, in dilution of mash, in heat, and in amount of sparging water, considerably affected the results, so that it was necessary to take the average of several determinations; it was not always possible to know at what temperature the malt would be mashed or sparged. Owing to these difficulties, he has now discarded this method as more troublesome and less reliable than that which will be presently described.

A method which is very largely adopted is that of Heron, as described in a paper read before the Society of Chemical Industry (*Society of Chemical Industry*, 1888, vol. vii., p. 259), and afterwards modified in a paper read before the Institutes of Brewing, in 1895 (*Journal of the Federated Institutes of Brewing*, vol. i., p. 116). This method consists in weighing out 50 grammes of ground malt, transferring to a flask, and adding 400 c.c. of water at such a temperature that the initial mixture heat may be 122° F. The whole is immersed in a water-bath and the temperature gradually raised, so that at the end of an hour it has reached 158°. The mash is now

raised to 190° for fifteen minutes, then cooled to 60°, and the whole made up to the bulk of 515 c.c. After being shaken, the liquid is filtered off, its specific gravity determined, and the extract calculated in the ordinary way, the assumption being made that the liquid occupies a bulk of precisely 500 c.c. There are several advantages in this method. The process is simple and rapid, no sparging is required; thus, errors due to that source are eliminated, whilst differences in mixture heat have very little influence upon the extract yielded, as is shown by the following figures:

Heron's Method.

Mixture-heat.	Extract per 336 pounds.
140° F.	95.2
150° F.	95
160° F.	95

It is a remarkable fact that whilst with thick meshes temperature exerts a very important influence on yield, with thin meshes practically no difference occurs.

But this method is not, in my opinion, entirely satisfactory. Heron, it will be remembered, makes up to a constant bulk of 515 c.c., yet there is a very great variation in the amount of husk contained in malt samples. This is abundantly evident to anyone who is accustomed to the analysis of malts, and the amount of husk present in a thin barley foreign malt is manifestly very much larger than that in a thin-skinned, plump, bold, English or Scotch barley malt. There is thus an error introduced due to this difference for which Heron has not made allowance. Further than this, the raising of the mash to 190° for fifteen minutes is open to the objection that, in practice, the mash never rises to such a temperature, very seldom (even during sparging) exceeding 160°.

Stern (*Journal of the Federated Institutes of Brewing*, vol. i., p. 448) proposes to overcome this source of error by making two meshes, both of which are mashed under Heron's conditions, but to one a known bulk of water is afterwards added. The specific gravity of the two filtrates is ascertained, and from that, by means of algebraic formula, it is possible to calculate the true extract. To those of us, however, who have in the course of a season to analyse a very large number of samples of malt, Stern's method is manifestly too laborious for practical application. The method which I propose eliminates the error arising from difference in amount of husk, and gives the true extract value of the malt sample. I proceed as follows:

Weigh out roughly a little over 50 grammes of the malt, and grind. Place the whole of the ground malt in a tared scoop, and accurately weigh 50 grammes. Now place the ground malt in an ungraduated ordinary boiling-flask of about 550 c.c. capacity, and run in as rapidly as possible a bulk of water at a temperature of 160° F., which shall be equal in volume to 400 c.c. if measured at 60° F. The measurement of this bulk of water is made in a flask or other suitable apparatus, graduated at the point occupied at 160° by 400 c.c. of water at 60°. Immediately thoroughly mix the contents of the flask. Loosely cork the flask to prevent evaporation, place in a water-bath maintained at a temperature of 150°, and allow to stand for two hours.*

* One hour's stand is usually sufficient, but for some malts a longer stand is necessary, and two hours' digestion insures complete extraction of all classes of malt.

At the end of this time cool the mash to 60° F., add 100 c.c. of water at 60°, mix thoroughly, filter bright, and take the specific gravity of the wort. We are now dealing with an actual bulk of 500 c.c. of liquid plus the volume occupied by the saccharine matter dissolved from the malt. It is necessary for us to ascertain what this volume is, and this we can calculate from the specific gravity of the liquid. To take an example: Suppose its specific gravity to have been 1028, now divide the excess weight over 1000 by the solution factor 3.86, $= 7.25$, the solid matter present in 100 c.c. of the wort. This multiplied by 5 ($7.25 \times 5 = 36.25$) gives us the amount of solid matter (36.25) dissolved from the malt. Now, as 15.9 parts of saccharine matter occupy a bulk when dissolved of 10 parts, it will be seen that the bulk occupied by the saccharine matter dissolved from the 50 grammes of malt is $15.9 : 36.25 :: 10 = 23$ c.c.

Our total dilution of mash is therefore 523 c.c., and this corresponds with the rate of 9.75 barrels per quarter. In order to further simplify the calculation, we may multiply our excess weight over 1000 of specific gravity direct by the factor 3.51, which gives the true extract per quarter of 336 pounds. Thus, $28 \times 3.51 = 98.2$ pounds per quarter of 336 pounds. In practice this factor may always be used. The variations in specific gravity which occur are not sufficient to materially affect the result.

The modified process, therefore, which I suggest, consists in mashing 50 grammes of malt with 400 c.c. of water at a mixture-heat of 150° F., standing for two hours, cooling to 60°, adding 100 c.c. of water, mixing, filtering, taking the specific gravity, and multiplying excess weight over 1000 by the factor 3.51.

DISCUSSION.

Dr. SYKES said he perfectly agreed with Mr. Briant as to the necessity that some definite scheme for analysing malt should be agreed on. The process Mr. Briant had suggested seemed to him to be a very ingenious one, and likely to surmount many difficulties.

Mr. ARTHUR R. LING said he thought most of those who had to make determinations of extract in brewery malts had found the method proposed by Mr. Briant in his well-known text-book too lengthy, although it undoubtedly gave results more in harmony with those obtained in actual practice than did the shorter methods. He had been in the habit of using the method devised by Mr. Heron, but, like Mr. Briant, he had had doubts whether the volume occupied by the grains from 50 grammes of the malt was always exactly 15 c.c., as it had been assumed to be by Mr. Heron. Recently, therefore, he had carried out the determination in a manner which did not necessitate such an assumption. Fifty grammes of the ground malt were added to 400 grammes of water, at the requisite temperature, contained in a tared beaker or flask. The mashing was conducted as usual, but, instead of ultimately making up the cooled mash to 515 c.c. with water, the beaker or flask was placed on a balance, and sufficient water weighed in that the total quantity (including that already present) amounted to exactly 500 grammes; the specific gravity of the filtrate was then determined as usual. It was only right to add that, as far as his experience

went, the results agreed with those obtained when working in accordance with Mr. Heron's directions.

Mr. JULIAN L. BAKER said that, as laboratory results were never absolutely representative of what took place in the mash-tun, it would be highly desirable that all brewing chemists should use one method for the determination of extract; and he personally preferred Heron's widely-used method on account of the very important desideratum—rapidity.

Mr. CHAPMAN said that the failure to make a determination of the available extract of a given sample of malt, or the incorrect determination of such extract, might result, as Mr. Briant had shown, in a considerable loss to the brewer, owing to the fact that unconsciously he might be obtaining from his malt a much smaller proportion of soluble matter than it ought to yield. If the malt contained soluble substances only, which had simply to be extracted, the matter would be a very simple one; but the determination had to be based on the amount of soluble matter formed as the result of a series of chemical changes, influenced by a number of conditions, and an approximation ultimately arrived at which should as nearly as possible represent the truth. From his own experience, he was of opinion that there could be no such thing as "the brewery extract" of a sample of malt; and that fact—at any rate, it appeared to him to be a fact—had led him to adopt a process yielding numbers which were always in excess of those obtained in the brewery, but which bore to the brewery extract a definite and (by him) understood relationship. Given one and the same malt, two brewers—situated, it might be, in the same street—would obtain two different quantities of extract, both perhaps working correctly, but using different procedure. The extract depended upon the precise character of the starch contained in the malt, or, in other words, the amount of modification which the contents of the grain had undergone, and also upon the procedure in the brewery itself—whether the mash was allowed to stand for a longer or shorter time; whether the mashing temperature was higher or lower; whether or not an underlet was used; whether a strong beer or a weak beer was being brewed, all of which were factors in actual working procedure, which exercised considerable influence upon the extract obtained. The possibility of ever arriving at a correct laboratory estimation of the "brewery extract," except by a compensation of errors or something of that kind, seemed to be precluded by several considerations. For instance, uniformity of grinding, which was referred to by Mr. Briant, was quite impracticable in the case of a heterogeneous material like malt. Moreover, laboratory experiments were necessarily made on a small scale, whereas in the brewery the extracts were determined when all the operations were concluded. The specific gravity was not by any means strictly proportional to the concentration; and a distinct error was introduced in the calculation of the small laboratory numbers to the large numbers of the brewery. Perhaps, therefore, after all, a purely arbitrary method was as likely to give satisfactory results as one in which an endeavour was made to closely imitate actual brewery practice. In addition to the intrinsic interest of Mr. Briant's paper, it was, he felt, of value as a plea for uniformity in various branches of analytical work; and there was no department in which the necessity for such uniformity was more marked than in the analysis of brewing materials.

Mr. HEHNER said that there were many articles besides beer in the case of which the chemist was called upon to make analyses of products which were afterwards used by the manufacturer; and the question arose as to what the manufacturer expected to learn from the analyses. Did he expect to learn how much the manufacturer's yield would be? or the actual quantity of any given constituent present in the article examined? In a gold ore, for example, the manufacturer desired to know how much gold was actually present; whether he got out that amount was another question, and probably in no two cases would the quantity turned out be the same. He (Mr. Hehner) himself made a great many analyses of crude glycerine, which was afterwards worked up into pure glycerine by distillation. He determined the actual percentage of glycerol present in the samples, not the quantity a manufacturer would expect to get out, which varied very widely. His function was to educate the manufacturer into a knowledge of what theoretically he might get out, it being the manufacturer's business to work as near to theory as possible. The same was presumably the case with malt. The chemist ought to say how much extract the brewer, with the most careful working, should be able to obtain. The brewer would understand that on a large scale there must be a certain loss, and that he would not quite reach the ideal.

Mr. LING said that if it were possible to estimate the starch in malt with anything like precision, a valuable scientific figure would be the extract calculated from the percentage of starch. The latter was the main extract-yielding constituent of the malt.

Mr. BRIANT, in reply, said that for many years he had made use of the process described by Mr. Ling. It was very good in its way, but there was still the same error arising from the solution of the sugar, which was not overcome any more than in the ordinary process of Mr. Heron. If merely the theoretical extract was to be given, then, as Mr. Ling had said, the starch could not be made the basis of calculation—at any rate, until a good method was devised for estimating it. If the theoretical extract was to be given, he thought it would be wise to adopt the recommendation of one of the Continental conferences—namely, that the whole of the malt should be ground to an extremely fine powder, and that the water should be at first cold, and gradually raised practically to boiling-point. Then everything extractible would be extracted, and something approaching uniformity might be hoped for between different chemists. But he doubted whether a figure so obtained would be appreciated by the brewer. He agreed to a certain extent with Mr. Hehner; but the brewer desired to get from his chemist some idea of the quantity of extract he was likely to obtain, perhaps by making a certain deduction from the figures of the chemist. Sometimes, for particular classes of beer, the brewer knowingly sacrificed extract, or, in other words, mashed at a temperature at which he knew the maximum extract would not be yielded. It paid him to do so in order to get quality. But he looked to his chemist for an approximate figure; and if a satisfactory figure of that kind was to be obtained, the endeavour should be made to eliminate an error such as occurred in all those processes in which no proper allowance was made for the difference in the quantities of husk in different samples of malt. This difference was considerable, and unless allowance was made for it, undoubtedly an error was introduced into the

analyses. No doubt, as Mr. Chapman had said, the absolute amount of extract could not be given which a brewer could obtain; but a comparative figure could be given, and the brewer would in practice be able to decide how nearly that figure approximated to his own result.

THE DETECTION OF ARSENIC IN BEER AND IN BREWING MATERIALS.

BY ALFRED C. CHAPMAN, F.I.C.

THAT the arsenic which has recently been detected in samples of beer was introduced through the medium of glucose or invert-sugar, in the manufacture of which arsenical sulphuric acid had been used, is now certain. Both to the private practitioner and to the public analyst this discovery is resulting in a very considerable influx of work; and it has been suggested to me that a brief account of the very extensive experience I have had during the past week or two in connection with the examination of beer and brewing materials for traces of arsenic might not be without interest to those members of our society who are now being called upon to examine such samples in connection with the Sale of Food and Drugs Act. To every chemist confronted with a problem such as this, the methods of Marsh and of Reinsch would naturally at once suggest themselves. Other methods, such as those of Fleitmann and of Gutzeit, in their original or modified forms are excellent in certain circumstances, and for purposes of obtaining additional confirmation perhaps, but they suffer under the great disadvantage of not yielding any characteristic and recognisable arsenic compound of a permanent and tangible nature—something, in fact, which can be preserved and brought forward as evidence should any dispute occur. I do not, indeed, think that any chemist would care to rely solely upon any method other than that of Marsh or of Reinsch in work of this character, and in cases which might give rise to legal proceedings, and which might ruin the reputation of a manufacturer. Of these two methods, that of Marsh is undoubtedly the more sensitive, provided that the arsenic in the organic matter to be dealt with can be got into a suitable form. This preliminary treatment is troublesome and takes much time, placing the process at a serious disadvantage as compared with that of Reinsch, where hundreds of samples have to be dealt with in a comparatively short time. If, on the other hand, an attempt is made to utilize Marsh's method working directly on the beer or sugar, then I am of opinion that not only is Reinsch's more convenient, but that it is at least equally sensitive. I have, in fact, on several occasions obtained much more distinct evidence of the presence of traces of arsenic in certain sugar materials by the latter than by the former, using in both cases simply solutions of the sugar itself.

The following is the procedure I have adopted for the detection of traces of arsenic in beer:

From 300 c.c. to 500 c.c. of the beer are transferred to a beaker, acidified with a few drops of hydrochloric acid, and heated on a sand-bath until the bulk of the alcohol has been driven off. A quantity of pure hydrochloric acid, roughly equal to one-fifth of the remaining volume of beer, is then added, and a small piece of copper-gauze, about $\frac{3}{4}$ inch $\times$ $\frac{3}{4}$ inch, attached to a copper wire, is then introduced. If at the

end of one hour's gentle boiling the copper has remained quite bright, it may safely be asserted that the beer was free from arsenic, or contained less than 1 part per 1,000,000 of arsenious acid. Should the copper be at all discoloured, however, it is removed from the beaker, thoroughly washed first in a stream of running water, then with alcohol, and finally with ether, after which it is dried thoroughly by gently warming it several inches above a small flame, and is carefully folded and introduced into a glass tube of small section, closed at one end, and about 3 inches long.

On gradually heating the end of this tube to redness (the tube being held in a nearly horizontal position), any arsenic present will become oxidized, and a crystalline sublimate in the form of a ring will be obtained. This, which has a very characteristic appearance to the trained eye, should then be examined by means of a $\frac{1}{4}$ -inch or $\frac{1}{2}$ -inch objective for the presence of the well-known crystal-forms assumed by arsenious oxide under these conditions.

In the case of heavy traces of arsenic, a $\frac{1}{2}$ -inch objective is sufficient; but for the sublimate which corresponds with a minute trace a $\frac{1}{4}$ -inch objective is necessary. It is, of course, well known that under these circumstances perfect octohedra are comparatively rare, the majority of the crystals being modified forms of the octohedron or tetrahedra. In the case of very faint sublimates the crystals have, as a rule, the appearance of minute triangles. Sulphites of various kinds are often added in small quantity to beer as preservatives, and when present will, of course, give rise to the formation of black copper sulphide, should any trace remain after the boiling above referred to before the insertion of the copper. This stain, however, remains unchanged when the copper is heated in the small tube, and, of course, gives no sublimate. Occasionally, too, a slight film of organic matter diminishes the brightness of the copper, but this also could not possibly be mistaken for arsenic.

Experimenting with samples of beer which gave not the slightest reaction for arsenic, I have found it quite possible to detect with certainty 1 part of arsenious acid in 1,000,000 parts, and have had no difficulty whatever in obtaining a well-formed crystalline sublimate with that quantity working with 400 to 500 c.c. of the beer. The copper gauze I have used is the finest obtainable, and it should be well washed with alcohol and then with ether before being used. Should it be at all tarnished when purchased, the alcohol and ether washings should be preceded by treatment with dilute nitric acid, as a brilliant metallic surface, free from grease, is essential to the detection of very minute traces.

In the case of glucoses, invert-sugars, and similar materials, I have worked on 50 grammes dissolved in 200 c.c. of water, and acidified with 50 c.c. of hydrochloric acid. Some of these substances carbonize considerably during the latter part of the hour's boiling, and it will be found very desirable to remove the copper at intervals of, say, ten minutes for inspection. Should a distinct discoloration occur during the first ten or fifteen minutes, the copper should then be removed and examined as above. In this way it is frequently possible to obtain an indication before the separation of carbon, which is apt to adhere rather strongly to the copper, and to so spoil the clearness of the crystalline sublimate. I may add that, when operating in the above manner, I have had no difficulty in detecting traces of arsenic when present as *arsenic acid*.

Carried out as above suggested, Reinsch's method will, I am sure, fully answer the requirements of public analysts when dealing with such materials as I have referred to, combining as it does ease and rapidity of execution with certainty of indication and sensitiveness. In addition to beers which were distinctly arsenical, and in which impure glucose or invert-sugar had been used, I have met with a considerable number containing *very minute traces* of arsenic, and in which it was within my knowledge that malt alone had been employed. On examining samples of malt, I discovered that, when working on 100 grammes, a considerable number gave reactions indicating the presence of an almost infinitesimal trace of arsenic; and in one or two instances I have been able clearly to demonstrate the connection between the presence of this exceedingly minute trace of arsenic in the malt and that present in the beer.

Whether this is due to the coal used for kilning, or whether it may not in some cases be referred back to the barley, remains to be shown; but it is obvious that the presence of very minute traces of so widely distributed an element as arsenic must be interpreted with caution. Its existence, for example, in wine containing no artificial colouring matter has already been recorded; and it is quite possible that it may be detected in a number of hitherto unsuspected natural products now that attention has been drawn to the matter in so striking a manner. The very minute traces I have above referred to give reactions which cannot for a moment be confounded with those yielded by beer which has been brewed or primed with arsenical sugar.

[Since the above communication was made to the society, the committee of experts appointed by the Manchester Brewers' Central Association has recommended a method for the detection of arsenic in beer identical in all essentials with that described.—A. C. C.]

DETECTION OF ARSENIC IN BEER.

BY ALFRED H. ALLEN.

THE recent correspondence in the papers, emanating chiefly from chemists who have been concerned in the deplorable epidemic of arsenical poisoning in Lancashire, has led to some interesting disclosures. Especially curious are the statements made respecting the delicacy of Marsh's test for arsenic, and its suitability for examining beer for that element.

Mr. William Kirkby states that it is doubtful whether Marsh's test, under the most favourable conditions, will indicate less than 1 grain of arsenic in 100,000 parts, or, say, about three-quarters of a grain per gallon of beer. This astounding experience may be contrasted with the statement of Mr. Frank Scudder—apparently rather on the dubious authority of the text-books than as the result of his personal experience—that a mirror on a porcelain basin in which you can see the reflection of your face can be obtained from one-forty-fifth of a gallon of a liquid containing 1 part of arsenious oxide in 700,000. But Mr. Scudder does not in practice employ these quantities, preferring to operate on not less than 1 litre of the beer.

Mr. William Thomson finds that, working on 150 c.c. of the beer, an amount of arsenic equal to one-hundredth of a grain of As_2O_3 can be detected with certainty by Marsh's test. He attributes the difficulty many analysts experience in detecting arsenic in beer to the imperfect or unsuitable methods they adopt to destroy the organic constituents of the liquid.

Mr. Chas. Estcourt has done good service by reminding analysts of the frequent presence of sulphites in beer, and of the fact that such beer will not give an arsenical mirror with Marsh's test. It is well known that sulphites evolve sulphuretted hydrogen when treated with zinc and dilute acid, and if this is produced in sufficient amount it may cause complete conversion of the arsenic into sulphide in the evolution-flask, and so remove it from the sphere of action. But I have in mind a case in which the material (burnt pyrites), when examined by Marsh's test, gave a yellow deposit of arsenious sulphide just beyond the heated part of the tube. At any rate, it is clear that sulphites interfere with the employment of Marsh's test, and should be previously removed. Mr. Estcourt effects this by boiling the beer for some time with acid before adding the metal. This appears to me an uncertain and tedious method, and I effect its immediate destruction by adding an oxidising agent, such as hydrogen peroxide, bromine-water, or potassium permanganate, to the acidulated beer. I prefer bromine-water, as it does not act on the organic matter so readily as permanganate, and the excess can be readily removed by a few minutes' boiling. Whichever plan be adopted, the arsenic is oxidised to the arsenic state, and some time elapses before the liquid will evolve arsenical hydrogen in Marsh's apparatus. This inconvenience I avoid by adding a few drops of a solution of cuprous chloride in hydrochloric acid to the contents of the evolution-flask. This reagent instantly reduces the arsenic to the arsenious state, and arsenical hydrogen is evolved almost immediately.* The use of cuprous chloride has the additional advantage that it results in the formation of a copper-zinc couple, and the evolution of hydrogen is much facilitated.

A working difficulty in the examination of beer by Marsh's test is met with in the persistent frothing of the liquid. This may be in a great measure overcome by previously boiling the beer till it is reduced to about half its original bulk. Even then a capacious flask is necessary. Oxidation of the organic matter also mitigates the difficulty.

Mr. W. Kirkby has described his method of applying Gutzeit's well-known mercuric chloride test for arsenic. He employs 3 c.c. of the beer, which is a proof of the delicacy of the test, and apparently its sole advantage. A yellow stain on a piece of filter-paper does not appeal to my mind in the same way as an arsenical mirror or the formation of crystals of characteristic form. Messrs. Paul and Cownley fully endorse this view, and consider that to obtain a satisfactory result with the mercuric chloride test is quite out of the question.

Messrs. A. Wynter Blyth and H. G. Madan independently recommend the treatment of beer with caustic alkali and aluminium, and utilise the reaction of the evolved

* A well-known analytical chemist informs me that, in his experience, the addition of cuprous chloride prevents the formation of arsenuretted hydrogen, but a careful retrial of my suggestion does not enable me to confirm this observation.

hydrogen with silver nitrate as a proof of the presence of arsenic. The method is very simple, and eliminates interference by the presence of sulphites or antimony; but the production of a black stain or precipitate does not appear to me so convincing as the formation of crystals.

I have recently had a considerable number of samples of beer to examine for arsenic, and find Reinsch's test to be the most satisfactory. The hydrochloric acid employed is purified by distilling off about one-tenth, this fraction containing the minute trace of arsenic originally present. I operate, as a rule, on 100 c.c. of the beer, and, as a preliminary treatment to eliminate sulphites, add hydrochloric acid and a little bromine-water, and boil the liquid for a few minutes. To obviate the difficulty caused by the fact that arsenic acid only responds to Reinsch's test after prolonged boiling and in presence of much acid, I next add a little solution of cuprous chloride in hydrochloric acid, which reduces the arsenic to the arsenious condition. On now introducing about 1 square centimetre of copper-foil and boiling, any arsenic is promptly deposited on the copper. The boiling is continued for thirty minutes, replacing any water lost by evaporation.* If the copper has then undergone darkening, it is dried in the water-oven, cut into strips, and heated in a narrow tube, when a characteristic deposit of arsenious oxide, in the form of microscopic octohedra or tetrahedra, will be obtained if the deposit on the copper was due to arsenic. Unless these crystals can be obtained, I am not satisfied that arsenic is present. The definition of the crystals is improved by filling the sublimation-tube with water, which acts only very slowly on crystallized arsenious oxide, and is preferable to alcohol.

This process has the advantage that the arsenic is actually seen and identified as such. Operating as above described, one part of As_2O_3 in 2,000,000 of beer gives a perfectly distinct reaction; but the delicacy of the test can be further increased by employing a larger quantity of the beer. Several sublimates can be united, and the arsenic again deposited on copper or subjected to Marsh's test.

The expert committee appointed by the Manchester Brewers' Central Association have issued a report in which they recommend Reinsch's test as the best for the detection of arsenic in beer. Unfortunately, they make no mention of the importance of insuring that the arsenic is in the arsenious condition. This omission has resulted in a reminder from Mr. J. A. Wanklyn that in 1861 an eminent German chemist (name not stated) made an elaborate investigation, which showed that 20 grains of arsenic "in one of its commonest forms" (form not stated in the original letter, but subsequently acknowledged to be arsenic acid), dissolved in a gallon of liquid, would remain undetected by the method recommended by the experts, or even on continuing the boiling for forty-five hours. A valuable detail in the experts' report is the direction to warm the upper part of the sublimation-tube before heating the copper. This precaution results in the deposition of larger crystals of arsenious oxide than can otherwise be obtained. It seems highly probable that when deposition of arsenic from an arseniate occurs in Reinsch's test, cuprous chloride has been previously formed by the action of the hydrochloric acid and atmospheric oxygen on the metallic copper, and that in the complete absence of air a negative reaction would be obtained.

* Dr. Dupré insists that the boiling should be conducted in a flask furnished with a reflex condenser, while other operators employ an open basin and encourage concentration by evaporation.

P.S.—Mr. A. E. Berry states that, in many cases where the deposit obtained in Marsh's test very closely resembled arsenic, on further investigation he found it to consist chiefly of "sulphur compounds." He suggests that "oxidised sulphites" are reduced to sulphuretted hydrogen by the nascent hydrogen produced in Marsh's test. "Oxidised sulphites" can only mean sulphates, and if these are reduced as alleged, a deposit of "sulphur compounds" would always be met with in applying Marsh's test.

ARSENIC IN BEER.

REPORT OF THE COMMISSION TO THE MANCHESTER BREWERS' CENTRAL ASSOCIATION.

GENTLEMEN,

The Commission have now examined the sugars and all the other materials used in brewing in Manchester (with the exception of the malt), and they consider that it is clearly established that the arsenic found in deleterious quantities in the beer has been solely due to the contamination by arsenic of the sugars supplied by Messrs. Bostock and Company, Limited, of Liverpool. The arsenic in these sugars was undoubtedly derived from the impure sulphuric acid used in their manufacture.

The measures recommended by the Commission a few days ago have, they learn, been effectively carried out. The whole of the beer in the manufacture of which any Bostock sugar was used has been destroyed, and there is no further danger from this source.

All the other brewing sugars on the English market have been analysed, and have been found to be quite free from arsenic.

In view of the importance of the matter, the Commission have instituted inquiries as to the manufacture of brewing sugars in the United Kingdom, and in this they have been assisted by the whole of the manufacturers of such sugars, in a body, voluntarily offering them the opportunity of examining into the mode in which they conduct the manufacture. These manufacturers have stated collectively that it is, and always has been, their custom to use only acid free from arsenic, and they have requested the Commission to examine their invoices, works, etc., in order to verify these statements. Lack of time has prevented this being done by personal examination up to the present, but the fact that all the specimens of brewing sugars, as well as of glucose used for other purposes, on the market have been found to be free from arsenic, and the absence of any previous cases in which arsenic has been in such products leave in the mind of the Commission no doubt that this statement, when examined into, will be found to be correct.

The Commission are quite unable to explain how Messrs. Bostock and Co., Limited, came to employ an acid of the character actually used by them. The absolute necessity of using an acid free from arsenic in the manufacture of an article for human consumption must have been evident to everybody technically connected with the manufacture, and such acid is a common article of commerce. The price

of the sugars in question was as high as any in the market, and, apart from this, the quantity of acid used in the manufacture of the sugars is so small that the difference in cost of the best and the worst would only make a difference of a fraction of a penny per hundredweight of sugar. So that it is not a case of an attempt to cheapen production by the use of lower priced materials. The Commission believe that it is this inexplicability which has rendered the matter so serious, and that the extent to which the mischief spread before it was detected was mainly due to the fact that the use of an acid containing arsenic in the manufacture of sugars was a contingency so improbable that it never occurred to those purchasing the sugars that it was possible that any danger could arise from that quarter.

The Commission have been unable to detect the presence of arsenic in brewing materials other than sugar supplied by Messrs. Bostock and Company, Limited; but they are aware that it has been asserted that traces of arsenic have been found in various samples of malt and hops. If such traces exist, they have probably been introduced in the operation of kilning, and the Commission propose to examine more fully into the matter. None of the specimens of hops have as yet yielded any traces. In any case, the amount so introduced would appear to be exceedingly minute, and not sufficient to have any deleterious effect.

The most important matter for the moment is to secure the adequate testing of beer, in order that the public may be protected from all further mischief. Arsenic is a substance which can be detected in the most infinitesimal quantities by those who are practised in the test; but these tests are so delicate that they are apt to mislead those who have not had experience in their application, and this is more particularly the case when the test is to be applied to a complex substance such as beer. Accordingly, the Commission have thought it necessary to investigate, and determine what is the most suitable method of testing beers for arsenic.

TEST.

The Commission recommend that the Reinsch test should be used in preference to all others at present known, because their investigations have satisfied them that it is the best and most reliable test for arsenic in beer. The mode of performing it is as follows:

Take 200 c.c. of the beer in a porcelain evaporating dish. Raise the liquid to the boiling-point, and then add 30 c.c. of pure concentrated hydrochloric acid. Insert a piece of pure bright copper foil, about $\frac{1}{4}$ inch by $\frac{1}{2}$ inch in size, and keep the solution gently boiling for forty-five minutes. If at the end of that time the copper remains bright and red, the beer is free from arsenic.

If a deposit is obtained on the copper, the foil is to be washed successively with water, alcohol, and ether (care being taken that these are pure), dried at a temperature not exceeding 100° C., and subjected to slow sublimation in a thin reduction-tube of small section, and not less than 2 inches long, the upper portion of which should be warmed before the sublimation begins. For the purpose of the sublimation, a small spirit-lamp flame should be used. If any sublimate is obtained, it must be examined

under a magnifying power of about 200 diameters. Any sublimate which does not show well-defined octahedral or tetrahedral crystals is not to be considered arsenical.

N.B.—It must be borne in mind that the blackening of the copper or a deposit thereon from the preliminary operation does not demonstrate the presence of arsenic in beer. Abundant blackening and deposit may be obtained from the purest beer.

LAUDER BRUNTON,
THOS. STEVENSON,
ALFRED GORDON SALAMON,
ARTHUR P. LUFF,
SAMUEL BUCKLEY,
J. FLETCHER MOULTON.

December 15, 1900.

SOIL SAMPLING.

ERRATUM.—In the report of Dr. Dyer's remarks on the sampling of soils, in the discussion of Mr. A. D. Hall's paper "On Uniformity in Soil Analysis" (p. 287), the following sentence occurs: "He (Dr. Dyer) had recently had a conversation with Sir Henry Gilbert on this subject, and learnt that at Rothamsted the view now held was to the effect that a more suitable depth would be one-fifth of a metre, viz., something under 6 inches—a convenient international measure." "6 inches" was a misprint for "8 inches."

ABSTRACTS OF PAPERS PUBLISHED IN OTHER JOURNALS.

FOODS AND DRUGS ANALYSIS.

On the Chemical Action of the Growth of Moulds upon Butter. J. Hanus and A. Stocky. (*Zeit. für Untersuch. der Nahr. und Genussmittel*, 1900, iii., 606-614.)—The authors have studied the chemical changes produced in butter by the growth of various moulds. The butter was used in the ordinary state in which it comes on the market, and for the purpose of the experiments was spread upon glass plates in thin layers. The moulds used were pure cultures. Preliminary experiments extending over three months were made with a variety of different moulds, and from the experience thus obtained, a further and more extended experiment was undertaken with the *Mucor mucedo*. The mould was allowed to vegetate for twelve months, the butter being examined before and after, and the results compared. The principal change noticeable was a great increase in the acid number, the acidity of the butter being augmented about twentyfold by the growth of the mould, and it would appear that these organisms have the power of resolving the glycerides into their constituent parts. At the same time, a secondary change, consisting in the production of bodies of an aldehydic character, was observed; but this the authors are not yet in a position to discuss.

H. H. B. S.

Detection of Gelatin in Fruit-Jellies. O. Henzold. (*Zeits. öffentl. Chem.*, 1900, vi., 292; through *Chem. Zeit. Rep.*, 1900, 260.)—The sample is diluted with water, boiled, and, if necessary, filtered. It is then mixed with excess of a 10 per cent. solution of potassium bichromate, brought to the boil, and cooled immediately by placing the tube in cold water. When cold, 2 or 3 drops (carefully avoiding more) of strong sulphuric acid are added. In presence of gelatin a precipitate appears, at first white and flocculent, soon cohering into lumps, and settling to the bottom of the liquid. No gelatinous substances derived from plants respond to this test, but hitherto it has not proved available for the quantitative determination of gelatin.

F. H. L.

Detection of Saccharin, Salicylic Acid, and Mixtures thereof. E. Riegler. (*Pharm. C. H.*, 1900, xli., 563; through *Chem. Zeit. Rep.*, 1900, 291.)—The reagent is a solution of *p*-diazonitraniline, prepared by dissolving 2.5 grammes of *p*-nitraniline in 25 c.c. of water and 5 c.c. of strong sulphuric acid, diluting with 25 c.c. of water, agitating with a solution of 1.5 grammes of sodium nitrite in 20 c.c. of water, and finally diluting to 150 c.c. The liquid is permanent if kept in the dark.

To detect saccharin, 0.01 to 0.02 gramme of the sample is dissolved in 10 c.c. of water, mixed with 2 drops of 10 per cent. sodium hydroxide, and poured into a 30 c.c. stoppered separating funnel. The reagent is added drop by drop with agitation till the green-yellow colour of the liquid disappears (about 10 drops are required). Ten c.c. of ether are next introduced, the whole is well shaken, the aqueous portion is run off, and the ether is treated with 20 or 30 drops of 10 per cent. sodium hydroxide. After agitating for half a minute, the liquid is allowed to separate, yielding a yellowish-brown aqueous portion and a green ethereal one. On running off the former and adding 5 c.c. of ammonia to the ether, it is decolorized, the ammoniacal liquor becoming blue-green.

To detect salicylic acid the manipulation is the same. The aqueous liquid is bright red, the ether colourless. After treatment with ammonia the ether is colourless, the aqueous portion red. To detect mixtures 0.02 to 0.03 gramme of the sample are taken and treated similarly. The ether is green, the water red. Ammonia decolorizes the former and itself becomes violet. The violet colour alters in shade according to the proportions of the two substances present.

F. H. L.

Composition and Determination of Cerium Oxalate. F. B. Power and F. Shedden. (*Journ. Soc. Chem. Ind.*, 1900, 636.)—The commercial salt employed for medicinal purposes contains about 40 per cent. of cerium oxalate, the remaining 60 per cent. consisting mostly of the oxalates of lanthanum and didymium. The authors find that these substances all have the general formula— $R_2'''(C_2O_4)_3 \cdot 10H_2O$.

The following qualitative test for cerium, due to Knorre, is extremely delicate: A gramme of the substance is heated with half a c.c. of sulphuric acid, 10 c.c. of water are added and a gramme of ammonium persulphate. On heating the liquid to boiling, a bright yellow colour is produced if cerium be present.

The most accurate method for estimating cerium in the presence of lanthanum

and didymium is based on the same principle (see ANALYST, 1898, 191). The cerium is oxidized to the ceric state by means of persulphate, and then the quantity of standard reducing solution required to reconvert it into the cerous condition is determined. Half a gramme of the oxalate is gently heated with 1 c.c. of pure sulphuric acid. When all effervescence has ceased, 100 c.c. of water are added. The solution should now be perfectly clear. If any precipitate separates out, it must be dissolved by the addition of more acid. A solution is made of 4 grammes of ammonium persulphate in 20 c.c. of cold water. The cerium solution is cooled somewhat below 50° C., 10 c.c. of the persulphate solution are added, and the liquid is again boiled for a minute or two. At this stage a precipitate often separates out, but it disappears as the oxidation proceeds. The remainder of the persulphate solution is added in exactly the same way in two separate lots of 5 c.c. each, the final boiling being prolonged to fifteen minutes. Four c.c. of sulphuric acid are now diluted with 20 c.c. of water, and added to the hot liquid. It is important to avoid the use of too much acid; otherwise the ceric salt may be reduced through the formation of hydrogen peroxide. The solution is now reduced to room temperature, and diluted to 100 c.c. Decinormal solution of ferrous sulphate is now run in until the deep yellow colour is entirely discharged. The excess of ferrous sulphate is determined by running in decinormal permanganate solution until the pink tint remains permanent for more than a few seconds. The number of c.c. of decinormal ferrous sulphate solution required per gramme of substance taken, multiplied by 1.40, gives the percentage of cerium.

Fairly accurate results may also be obtained by digesting the ignited oxides with potassium iodide and hydrochloric acid, and determining the iodine liberated. The presence of praseodymium makes the results high. The ignited oxides from half a gramme of oxalate are placed in a 100 c.c. stoppered bottle, with a gramme of potassium iodide and 5 c.c. of hydrochloric acid. If the oxides are brown, showing the presence of didymium, 5 c.c. of water are also added. The air is displaced by carbon dioxide, and the bottle is placed on the top of a steam-oven, and rotated from time to time for about half an hour until solution is complete. When the bottle is cool, 50 c.c. of water are added, and the solution is titrated with decinormal thio-sulphate solution in the usual way.

In making a complete examination, determinations may also be made of the oxalic acid by titration with permanganate solution, and of the residue left on ignition, which should consist almost entirely of the oxides of cerium, lanthanum and didymium.

A. M.

TOXICOLOGICAL ANALYSIS.

Note on a Method of detecting Free Phosphorus. P. Mukerji. (*Chem. News*, lxxxii., 205.)—The method depends on the phosphorescence of phosphorus vapour diluted with hydrogen. The apparatus used consisted of a three-necked Woulffe's bottle; a safety funnel dipping into the liquid in the bottle is fitted in one neck, a short jet, and a wide tube, about 11 inches long, and closed by a cork,

being inserted in the other two, so as to enter the bottle for a short distance only. The wide tube is loosely fitted to allow traces of air to enter the bottle. To carry out the test, zinc and dilute sulphuric acid are placed in the bottle. When the mixture has become hot, the substance to be examined is introduced, and the appearance of the issuing gas observed in a dark room. If phosphorus is present, it will glow. If the cork is then taken out of the wide tube, the glow will sink through the jet and appear at the top of the wide tube, but it reappears at the jet if the cork is replaced.

The test is at least as delicate as that of Mitscherlich; 2 milligrammes of phosphorus could be detected in the presence of 112 grammes zinc, 250 c.c. dilute sulphuric acid, and 30 c.c. milk. By passing the vapour through silver nitrate solution, the phosphorus may be estimated quantitatively. Many substances which interfere with the detection of phosphorus by other methods, especially phosphorous compounds, do not affect this one.

Before opening the bottle used for the experiment, it should be filled with water.
A. G. L.

Detection of Digitalis in Cases of Poisoning. D. Vitali. (*Boll. Chim. Farm.*, 1900, xxxix., 597; through *Chem. Zeit. Rep.*, 1900, 301.)—Of the various constituents of digitalis, digitoxin exists in the largest proportion, and seems to be the body which is best sought for in cases of poisoning. To test the possibility of detecting it, a mixture was prepared of 200 grammes of chopped horseflesh, 100 grammes of urine, and 3 grammes of powdered digitalis. This was macerated for twenty-four hours, evaporated to dryness on the water-bath, and the residue extracted twice with 70 per cent. alcohol. The liquid was filtered, the spirit distilled off, the aqueous portion concentrated to half its bulk, and precipitated with lead acetate, removing the excess with sodium sulphate as usual. The filtrate was made alkaline with ammonia, and extracted with chloroform. On evaporation of the latter, a pale residue was left, which was again taken up in chloroform and treated with a mixture of 1 part of ether and 7 parts of petroleum spirit to throw down the digitoxin. The precipitate was dissolved in alcohol, evaporated, and taken up in ether. The solid matter contained in the ether was scarcely visible, but it gave the Keller test: It was dissolved in 2 c.c. of a solution of 1 part of ferric chloride in 500 parts of glacial acetic acid, and floated on strong sulphuric acid, when a red-brown colour appeared between the liquids, which afterwards changed to blue. In the aqueous liquid left after extraction with chloroform, digitonin and digitalin ought to be found, but the tests failed, and they are probably only capable of being recognised when large doses of digitalis have been administered.
F. H. L.

ORGANIC ANALYSIS.

Modification of Ritthausen's Process for determining Albumin. F. Barnstein. (*Landw. Versuchsst.*, 1900, liv., 327; through *Chem. Zeit. Rep.*, 1900, 313.)—Instead of endeavouring to throw down the precipitate of copper oxide and albumin by completely neutralizing the liquid with sodium hydroxide, the present author prefers to add a measured quantity of alkali insufficient to throw the whole of the copper out of solution. In this way the difficulty of exactly neutralizing a coloured liquid is avoided, the solutions are more easily prepared and keep better, and the use of alum, which is inconvenient with substances containing much potassium phosphate, is not necessary. One or 2 grammes of the sample are boiled, or heated for ten minutes on the water-bath, with 50 c.c. of water, and then mixed with 25 c.c. of copper sulphate solution containing 60 grammes of crystals per litre. Twenty-five c.c. of caustic soda (12.5 : 1,000) are next introduced, and the whole is allowed to settle. The precipitate is washed by decantation, then brought on a filter, and washed till free from copper and sulphuric acid. The nitrogen in it is finally estimated by the Kjeldahl process. The results agree well with those obtained by the Stutzer method. In substances such as tea, tobacco, etc., which contain alkaloids or other nitrogenous constituents, however, rather more nitrogen is recovered; but alkaloids, etc., never occur in sufficient quantity in food-stuffs to render a distinction between them and the albumin requisite. Barnstein's process does not throw down peptones entirely, but the basic copper precipitate of either vegetable or animal albumin always contains more nitrogen than Stutzer's copper hydroxide precipitate, as might be expected.

F. H. L.

Preparation of Paper for Microscopic Examination. W. Herzberg. (*Mitth. Kgl. techn. Versuchsanstalten*, Berlin, 1900, xviii., 86; through *Chem. Zeit. Rep.*, 1900, 254.)—In order to obtain the fibres in a fit state for microscopic examination, unsized paper—blotting, filter, and “half-stuff,” etc.—is disintegrated by boiling in water; and materials containing wool are treated similarly. All other varieties are boiled with 4 per cent. sodium hydroxide, cardboard and the like being first split into thin sheets, to allow the alkali to penetrate more thoroughly. The pulp, which is already of a yellow-ochre colour from the action of the soda if wood-fibre is present, is strained through a fine sieve, and washed with water. It is next brought into a wide-necked stoppered flask, half full of water and containing some small pebbles; and the whole is shaken till all lumps are broken down. The product is filtered, and is then ready for examination under a power of 150 diameters. Two stains may be employed to assist in the identification of the various fibres: (A) potassium iodide, 2 grammes; iodine, 1.15 grammes; glycerin, 2 c.c.; water, 20 c.c.; (B) zinc chloride, 20 grammes; water, 10 c.c.; potassium iodide, 2.1 grammes; iodine, 0.1 gramme; water, 5 c.c.: mixed together, clarified by subsidence, and treated with a crystal of iodine. The effects are as follows:

				A.	B.
Linen, hemp, cotton	...	...	...	Black to dark brown; thin scales almost colourless.	Faint to strong wine red.
Wood-cellulose, Adamsonia	...	...	...	Gray to brown.	Blue to red-violet.
Straw-cellulose, jute	...	...	...	Gray.	Blue to blue-violet.
Esparto	...	...	...	Partly gray, partly brown.	Partly blue, partly wine red.
Manila	...	...	...	In parts gray, brown, and yellow-brown.	Blue, blue-violet, red-violet, dirty yellow, and greenish-yellow.
Wood-powder, raw jute, etc.	...	...	...	Yellow-brown and yellow, according to thickness.	Lemon to dark yellow.
Straw-stuff	...	...	...	Yellow-brown, yellow, gray.	Yellow, blue, blue-violet.

F. H. L.

Estimation of Starch in Potatoes. G. Baumert and H. Bode. (*Zeit. angew. Chem.*, 1900, 1074 and 1111.)—The authors have devised a method for determining directly the amount of true starch in potatoes. The cellulose is first removed by digesting in an autoclave and filtering. The starch is then separated from nitrogenous and other substances, by precipitation with alcohol in alkaline solution. It is thus obtained mixed only with a little inorganic matter. The weight of starch is found by determining the loss on ignition.

Of the finely-ground air-dry material, 3 grammes are weighed out and stirred with 50 c.c. of water in a porcelain beaker. This is allowed to stand about half an hour, with occasional stirring; then the liquid is decanted off through a small asbestos filter. The filter is put back in the beaker, 50 c.c. of water are added, the beaker is covered and is heated for three and a half hours in a Soxhlet autoclave at about 3 atmospheres pressure (not more). When cool, the contents are transferred into a 250 c.c. flask, washing in with boiling water. This is then boiled for ten minutes, allowed to cool, and filled up to the mark. It is thoroughly mixed, 100 c.c. are filtered off, and 10 c.c. of 10 per cent. caustic soda solution are added to the filtrate, whereon the opalescent liquid becomes clear. Twenty-five c.c. of this and 100 c.c. of alcohol (94 to 96 per cent.) are stirred together in a beaker; before the precipitate collects together about a gramme of finely-divided asbestos is added, and the liquid is stirred vigorously until the precipitate settles quickly, leaving the solution clear. If this does not occur in about a minute, more asbestos should be added. The liquid is now decanted on to an ignited asbestos filter, and drawn through. The precipitate is stirred with 80 per cent. alcohol, brought on to the filter and washed, taking care not to press the precipitate or to allow it to become dry. The beaker is washed round with 3 to 5 c.c. of 5 per cent. hydrochloric acid, 25 to 30 c.c. of alcohol are added to reprecipitate starch, and this is poured on to the filter, which is now washed first with 80 per cent. alcohol, then with absolute alcohol, and finally with dry ether. The filter-tube is then dried to constant weight at 120° to 130°, with a current of air passing through it. After weighing, the tube is

ignited with a current of air or oxygen passing through, and then again weighed. The loss of weight is the quantity of true starch in $\frac{3}{11}$ gramme of the air-dry material.

The method gives concordant results, which agree with those obtained by inverting and estimating the starch as dextrose. In a sample of purified starch, 85.39 per cent. was found, as against 85.17 per cent. estimated by difference after determining the moisture and impurities.

A. M.

Digestion and Assimilation of Pentoses and Furfuroids. C. F. Cross, E. J. Bevan, and J. S. Remington. (*Journ. Amer. Chem. Soc.*, 1900, 630.)—The authors have performed digestion experiments with the furfuroid-yielding constituents of plant tissues, which are generally termed pentosans, but which the authors prefer to call furfuroids. These were extracted from brewers' grains by digestion with 1 per cent. sulphuric acid at 130° C., and purified by neutralizing, filtering, evaporating. The extract when tested by distillation with hydrochloric acid gave 3.95 per cent. of furfurol, calculated on the dry weight. It was found that the product, mixed with gelatin, bread, and fresh vegetable food, was practically entirely assimilated when administered to rabbits.

A. M.

Digestibility of some Non-nitrogenous Constituents of Certain Feeding Stuff. G. S. Fraps. (*Journ. Amer. Chem. Soc.*, vol. xxii. [9], pp. 543-552.)—The conclusions drawn by the author from the experiments detailed in the paper are that the sugars in feeding stuffs are, as a rule, completely digested, and their determination is of special importance in the case of hay and cotton-seed meal. The average digestibility of pentosans (thirty-four samples) is 64.2, or in eight samples of timothy hay 53.9. The order of digestibility of the non-nitrogenous extractive matter is (1) sugars, (2) starch, (3) pentosans, (4) residue. The pseudopentosans of crude fibre are less digestible than the residue, whilst the latter is sometimes more digestible, in other cases less so, than the residual non-nitrogenous extract. Crude fibre may undergo such alteration in the digestive process as to appear as non-nitrogenous extract in the excrement, and its estimation is less important than that of sugar, starch, and pentosans.

C. S.

Extraction of Fat from Animal Organs. G. Rosenfeld. (*Centralb. inn. Med.*, 1900, xxi., 833; through *Chem. Zeit. Rep.*, 1900, 250.)—It is well known that mere extraction with ether does not suffice to recover all the fat from animal organs. Pflüger and Dormeyer have suggested submitting the materials to a previous peptic digestion, and then treating with ether; but the process is tedious and complicated. By extracting the organs for six hours with chloroform in a Soxhlet, the results are similar to those of the Dormeyer process; but still higher figures are obtained if they are first boiled for a short time with alcohol. The final solutions are evaporated, the residue placed for a time in a drying oven, then dried thoroughly in the desiccator, taken up once more in cold absolute ether, evaporated and dried again,

thus insuring that only substances really soluble in ether are weighed. Nevertheless, the products of these various methods exhibit differences, especially in their iodine values.

F. H. L.

Estimation of Carvone in Essential Oils. J. Walther. (*Pharm. C. H.*, 1900, xli., 613; through *Chem. Zeit. Rep.*, 1900, 313.)—Carvone is the valuable ingredient of the oils of mint and caraway. It may be determined by converting the ketone into oxime, and titrating the excess of hydroxylamine employed. Two to 5 grammes of carvone, or oil containing it, are mixed with 10 grammes of a fresh aqueous solution (2:3) of hydroxylamine hydrochloride; 25 c.c. of alcohol free from aldehyde and 2 grammes of sodium bicarbonate are added, and the whole is placed on a boiling water-bath under an upright condenser for half an hour. When cold, 6 c.c. of 1·12 hydrochloric acid are introduced, and the liquid is brought into a 500 c.c. flask, rinsing the apparatus with dilute HCl. The solution is diluted to the mark, filtered, and in 25 or 50 c.c. of the filtrate the unused hydroxylamine is titrated with decinormal sodium hydroxide, 1 c.c. of the latter being equivalent to 0·015 gramme of carvone.

F. H. L.

Investigation of the Value of the Halphen Colour Test for the Detection of Cotton-seed Oil. Rozier D. Oilar. (*Amer. Chem. Journ.*, xxiv., 355.)—The author has thoroughly investigated the reliability of the test. As recommended by him, it consists in heating 10 c.c. of the oil or melted fat under examination with 10 c.c. of amyl alcohol, and 10 c.c. of carbon disulphide containing 1 to 2 per cent. of dissolved sulphur in a boiling-tube, at first, with frequent agitation, in a steam-bath, and then, after the violent boiling has ceased, in a boiling salt-water bath (temp. 105 to 110°) for from forty-five minutes to three hours, according to the quantity of oil present, the tube being occasionally removed and shaken. As little as 1 per cent. of cotton-seed oil will give a beautiful crimson wine coloration in twenty minutes. If the mixture is heated for too long a time, a misleading brownish-red colour, due to burning, may be produced.

The reaction does not appear to be produced by any other of the common edible oils or fats, nor by the various fillers and colourings used with hog fats. It is more sensitive with fresh than with old fats, and a faint colour is still given by fresh lards containing only $\frac{1}{16}$ per cent. of cotton-seed oil, noticeable when compared with a blank test; with $\frac{1}{4}$ per cent. it is perfectly reliable.

The test may be directly applied to the soap or fatty acids of a fat mixture of high percentages of cotton oil, if not too deeply coloured, but the reaction is not so delicate. It may also be used as a test for free sulphur. The author gives tables showing the results obtained with various mixtures.

A. G. L.

Acid and Saponification Values of some Copals. W. Lippert and H. Reissiger. (*Zeits. angew. Chem.*, 1900, 1047.)—To determine the acid value, 10 c.c. of chloroform are poured upon 1 gramme of the copal, and after standing some hours 25 c.c. of alcohol are added. If the copal does not dissolve, it is necessary to

use ether, or ether and alcohol. When solution is complete, it is titrated with semi-normal alcoholic potash, using phenolphthalein as indicator.

To determine the saponification value, the copal is heated with alcohol and ether (chloroform must not be used), excess of standard alcoholic potash is added, and the determination is carried out as usual.

The ether value is the difference between the acid and saponification values. In the case of Manila copal, and perhaps in other cases, it is due, not to esters, but probably to lactonic bodies.

Copal.	Acid Value.	Saponification Value.	Ether Value.	Remarks.
Angola, white ...	59-61	—	—	Williams found acid value 57
„ red ...	90	148-152	58-62	Schmidt and Erban found saponification value 148
Angostura ...	48	—	—	Fine glassy yellow lumps
Benguela, elect ...	61-62	111-126	50-64	Clear yellow balls
„ ordinary ...	84-87	—	—	Contains dirt
Brazil, elect ...	153-158	148-157	1-5	Splendid pale yellow balls
Cameroon ...	106-109	—	—	Easily soluble in alcohol
Cowry, elect ...	81	—	—	Not quite transparent
„ light ordinary ...	63-64	95-109	32-39	Williams found saponification value 64.2
„ dark ...	66.5-70	—	—	—
Dammar ...	33-35	—	—	Completely soluble in turpentine
Madagascar ...	60	—	—	Easily soluble in alc.-chloroform
Manila, elect ...	103-111	147-152	44-50	Hard, easily soluble in alcohol
„ sol. spirit ...	144-148	—	—	Soft, „ „ „
Sierra Leone ...	78-82	—	—	Small light balls
Zanzibar ...	—	88-102	—	Characteristic "goose-skin" appearance

Copals are practically always melted before being used for making lacquers, etc. The behaviour on melting is therefore the most important property to determine. The quantitative reactions described are, however, useful for detecting adulterants.

Artificial resins are made by heating colophony with glycerin, thus producing esters of the resin acids. The products thus obtained should have an acid value not higher than 20.

A. M.

Volumetric Method for the Estimation of Carbon Monoxide in Coal Gas.

A. Smits, H. Raken, and P. C. E. M. Terwogt. (*Zeits. angew. Chem.*, 1900, 1002.)

—After other constituents have been absorbed by potash, fuming sulphuric acid and phosphorus, the carbon monoxide is absorbed by means of the arrangement described by the authors. This consists of a U-tube filled with solid iodic anhydride. This tube is connected on the one side to the Hempel burette, and on the other to a pipette containing potash solution. The gas is passed several times backwards and forwards through the U-tube, by which means the carbon monoxide is oxidized to carbon dioxide, which is absorbed by the potash— $5\text{CO} + \text{I}_2\text{O}_5 = 5\text{CO}_2 + \text{I}_2$.

A. M.

INORGANIC ANALYSIS.

On the Qualitative Separation of Nickel from Cobalt by the Action of Ammonium Hydroxide on the Ferricyanides. Philip E. Browning and John B. Hartwell. (*Zeit. Anorg. Chem.*, 1900, xxv. 323.)—The authors urge two objections against F. W. Clarke's method (*Amer. Journ. Sci.*, xlviii., 67): first, the difficulty of obtaining a good filtration from the cobalt ferricyanide; and, second, the large amount of sulphur thrown down on the addition of ammonium sulphide to the filtrate.

The following modification does not suffer from these defects: To not more than 0.1 gramme of the mixed salts dissolved in 5 c.c. of water, a few drops of a solution of alum are added; the solution is then neutralized with ammonia, acidulated with acetic acid, 0.5 gramme of potassium ferricyanide added, the liquid agitated, and filtered after the addition of 5 c.c. of strong ammonia. Cobalt is recognised by the colour of the precipitated ferricyanide, and nickel is indicated by the black precipitate of nickelic hydroxide obtained in the filtrate on heating it to boiling with a small piece of sodium hydroxide. By this method, as little as 0.0002 gramme nickel can be detected in the presence of 0.05 gramme cobalt sulphate. A. G. L.

The Iodometric Estimation of Arsenic Acid. F. A. Gooch and J. C. Morris. (*Zeit. anorg. Chem.*, 1900, xxv., 227.)—By the action of a soluble arsenate on a soluble iodide in acid solution, the arsenic acid is reduced to arsenious acid more or less completely according to the conditions. In order to make the reaction complete, it is necessary to remove the iodine set free. This may be done either by running in thiosulphate or by evaporating down, the last traces being then removed by careful addition of sulphurous acid. After reduction the arsenic can be determined by neutralizing with a bicarbonate and titrating with iodine, the arsenious acid being thus reoxidized to arsenic acid.

Methods based on reduction with thiosulphate give inaccurate results, on account of other reactions taking place, whether the determination be made by direct titration with thiosulphate or by titration with iodine after neutralization. The iodide becomes oxidized by the air, and the thiosulphate is acted upon by the acid. On the other hand, by evaporating the iodine off accurate results may be obtained.

The arsenate is heated in an Erlenmeyer flask, with an excess of potassium iodide (0.5 gramme more than is theoretically required) and 10 c.c. of dilute sulphuric acid (1:1), the total volume of the liquid being 50 to 75 c.c. The liquid is boiled until iodine vapour can no longer be seen, and is then decolorized by the careful addition of sulphurous acid. It is now rapidly diluted with cold water and cooled, nearly neutralized with caustic potash, and then entirely neutralized with potassium bicarbonate. Finally starch is added as indicator, and the reduced acid is titrated with iodine solution. A. M.

Investigation of Millon's Reagent. W. Vaubel. (*Zeit. angew. Chem.*, 1900, 1125.)—This reagent is prepared by dissolving 1 part of mercury in 1 part of cold fuming nitric acid (specific gravity 1.4), warming and adding 2 parts of distilled water. With phenol and certain substituted phenols in aqueous solution it gives

a red precipitate. The author finds that the reaction only takes place if there be unsubstituted hydrogen atoms in both an ortho- and a meta- position relative to the hydroxyl group. It does not take place, therefore, with di-ortho- or di-meta- substituted phenols. Of the naphthols and those of their derivatives examined, β -naphthol was the only one which gave the characteristic precipitate.

The reaction is due to the presence of mercurous nitrate and nitrous oxide. If sodium hydroxide be added, the red precipitate dissolves, giving a red solution.

A. M.

The Estimation of Tungsten in Steel and Steel-making Alloys. Fred Ibbotson and Harry Brearley. (*Chem. News*, lxxxii., 224.)—The powdered steel is heated with hydrochloric acid (100 c.c. for 5 grammes steel) just short of boiling, and a minimum amount of nitric acid gradually dropped in, until the sample has completely dissolved and all the iron is in the ferric condition. The solution is then boiled till WO_3 just begins to separate, diluted with twice its volume of water, and again boiled, when all the WO_3 except 2 or 3 milligrammes will be precipitated. In the ignited precipitate SiO_2 is estimated by means of HF, and then traces of F_2O_3 and Cr_2O_3 , after fusion with sodium carbonate. The process is rapid, and results obtained with it are only about 0.05 per cent. too low.

Ferro-Tungsten Alloys.—As at most only 2 grammes can be handled, the error of the above method amounts to about 1 per cent. of the tungsten. For an accurate analysis the solution of the alloy is evaporated to dryness on the water-bath, the residue boiled with dilute hydrochloric acid, and the $\text{WO}_3 + \text{SiO}_2$ filtered off. Any molybdenum present will be in solution.

Nickel-Tungsten Alloys.—The powdered alloy is dissolved in HF and HNO_3 , and evaporated with sulphuric acid till fumes of the latter come off. After diluting, WO_3 is filtered off, and nickel estimated by the cyanide process in the filtrate. For a complete analysis the sample is treated like a ferro-tungsten, molybdenum estimated as PbMoO_4 , and nickel with potassium cyanide.

Tungsten-Molybdenum Steels.—The following method gives good results: The steel is dissolved as in the case of tungsten steels, the solution just evaporated to dryness, the residue boiled with dilute hydrochloric acid, WO_3 filtered off, and in the filtrate molybdenum and iron are separated with sodium hydroxide (*Chem. News*, lxxxi., 269).

Tungsten Powders.—The authors have noticed the presence of peculiar red crystals, possibly of tungsten bronze, which they have not been able to estimate accurately.

A. G. L.

Determination of Ferrous Iron in Minerals. W. F. Hillebrand and H. N. Stokes. (*Journ. Amer. Chem. Soc.*, 1900, 625.)—Mitscherlich's method of heating the mineral with sulphuric acid in a sealed tube gives high results, if any sulphides be present. This is due to the fact that the ferric iron is reduced by the sulphides. Accurate results are obtained by Cooke's hydrofluoric acid method. The silicate is decomposed by heating for an hour in a large platinum crucible on the water-bath, with dilute sulphuric and hydrofluoric acids. The cooled contents are poured into a

platinum dish containing water, and rapidly titrated with permanganate nearly to the end. If sulphides be present, the solution is now filtered through a filter-paper supported on a platinum cone. The titration is then carried to the end. The pink colour will only be transitory, because the hydrofluoric acid acts on the excess of permanganate.

A. M.

Estimation of Pyrrhotite in Pyrites Ore. F. B. Carpenter. (*Journ. Amer. Chem. Soc.*, 1900, 634.)—The presence of pyrrhotite (Fe_7S_8) is shown by its adhering to a magnet. The author's method for estimating it is based on the fact that pyrites (FeS_2) is practically insoluble in concentrated hydrochloric acid, whereas pyrrhotite is soluble. The quantity of material insoluble in hot concentrated hydrochloric acid is determined; from this the silica is deducted. From the percentage of pyrites thus obtained, and the total sulphur, the percentage of pyrrhotite is then calculated.

A. M.

A New Method for the Determination of Aluminium. E. T. Allen and V. H. Gottschalk. (*Amer. Chem. Journ.*, xxiv., 292.)—The method depends on the precipitation by carbon dioxide from the solution of an aluminate of a basic carbonate of aluminium containing a little alkali, which is converted into the normal hydroxide when boiled with water containing some ammonium salt. The authors state that the hydroxide obtained in this way is much denser and more easily washed than the ordinary precipitate obtained with ammonia, and that consequently much larger quantities can be handled. Accurate results are also obtained in the presence of sulphates, but alkaline earths and lithium must be absent.

For the determination the aluminium solution is nearly neutralized with ammonia, if acid, and a fresh solution of potassium hydrate run in from a burette until the precipitate is completely redissolved. The quantity of potassium hydrate added should be known, so that the amount of the impurities (silica, iron, alumina) may be deducted from the weight of alumina obtained. Through the alkaline solution a stream of carbon dioxide is then passed for some time, the precipitate transferred to a filter, washed, replaced in the original beaker, and boiled with about 200 c.c. of water containing a little ammonium chloride or nitrate for two or three minutes. The supernatant liquid is then decanted through another filter, using the filter-pump, the boiling and decantation repeated once or twice, and the aluminium hydroxide finally washed with water, ignited, weighed, re-ignited and reweighed. The average error of the method is less than 0.01 per cent. (0.045 to 0.004 per cent.).

A. G. L.

Determination of Free Alkali in Soap. R. E. Divine. (*Journ. Amer. Chem. Soc.*, 1900, 693.)

Total Free Alkali.—Two grammes of the sample are boiled for half an hour with 50 c.c. of alcohol and a measured excess of a standard alcoholic solution of stearic acid. The excess of acid is then determined by titration with caustic soda, using phenolphthalein as indicator. The acid absorbed is equivalent to the total free alkali.

THE ANALYST.

Caustic Alkali.—Two grammes of the sample are dissolved in 50 c.c. of alcohol, a slight excess of barium chloride is added, and the solution is heated for a few minutes. It is then titrated with standard stearic acid solution, using phenolphthalein as indicator. The titration must be performed slowly with constant agitation. The acid added is directly equivalent to the caustic alkali. A. M.

A New Indicator for Acidimetry, and its Application to the Determination of Alkali-metal Carbonates and Boric Acid. J. Wolff. (*Zeit. für Untersuch. der Nahr. und Genussmittel*, 1900, iii., 600-605.)—The author's proposal is based upon the fact that if salicylic acid be dissolved in an excess of sodium hydroxide with the addition of a little ferric chloride, and the excess of alkali be then titrated with sulphuric acid, a blood-red coloration changing to violet is produced when the point of saturation is reached. Observations show that the exact point of neutralization coincides with the production of the blood-red colour. The reaction is not only exceedingly delicate, but its sensitiveness increases with the dilution of the solutions. The author prepares the indicator as follows: Six grammes of sodium salicylate are dissolved in 25 c.c. of distilled water, and a dilute solution of ferric chloride is added drop by drop until a slight permanent turbidity is produced. The solution is then filtered, made up to 200 c.c., and divided into two equal parts, one of which is adjusted with soda to the point indicated by the production of a dark orange colour, and the other with acid to the point indicated by the production of a red. The two solutions are then mixed together, and 10 grammes of sodium salicylate added.

The author specially recommends the indicator for use in determining potassium and sodium carbonates. It at first colours solutions of these salts yellow, but as carbonic acid becomes liberated, the colour changes to red, and finally, with the slightest excess of sulphuric acid, to violet. He also applies it to the determination of boric acid in borax, and to the analysis of mixtures of boric acid and borax. To an exact quantity of the substance dissolved in water, a known excess of normal sulphuric acid is added, and the solution titrated with normal soda by the aid of the indicator. Glycerin is then added, and the solution again titrated with soda, using phenolphthalein as the indicator. The test results given are good. H. H. B. S.

REVIEWS.

VICTOR VON RICHTER'S ORGANIC CHEMISTRY; OR, THE CHEMISTRY OF THE CARBON COMPOUNDS. Edited by Professor R. ANSCHUTZ, University of Bonn (assisted by Dr. G. SCHRÖTTER). Authorized translation by Professor EDGAR F. SMITH, University of Pennsylvania. Third American, from the eighth German, Edition. Volume II.: Carbocyclic and Heterocyclic Series. Pp. 671. London: Kegan Paul, Trench, Trübner and Co., Ltd., 1900. Price 15s.

The volume before us completes the third American edition of "Richter's Organic Chemistry." It deals not merely with aromatic compounds, *i.e.*, derivatives of benzene and allied substances, but with all compounds whose constitutional formulæ are represented by closed chains or rings. It may be mentioned, however, that the so-called alicyclic compounds (for example, certain lactones), which are closely related

to, and derived by simple reactions from, members of the aliphatic series, are simply catalogued, their general properties having been dealt with in the first volume.

Bearing in mind that the literature of the aromatic compounds alone is more voluminous than that of all other departments of chemistry taken together, the scope of a work such as the one before us presents considerable difficulties. The editor certainly deserves the highest praise for the discretion he has exercised in this direction. Not only has the number of pages in the two volumes been kept remarkably even, but the matter is dealt with in a manner as it should be in companion volumes. We have already observed, in dealing with the first volume, that the work has, in a sense, outgrown the scope of a text-book, and it will doubtless serve many as a book of reference. In this connection the references to the literature form an important feature, and it is to be regretted that some of these refer to abstracts, and not to the original papers. Instances may be cited in the references given to G. Goldschmidt's work on papaverine, and that of W. H. Perkin junior on berberine.

The volume appears commendably free from typographical errors, and the translator has, on the whole, executed his task satisfactorily; yet the diction is not faultless, and we could point to several passages which are by no means clear.

A. R. L.

CHEMISTRY: AN EXACT MECHANICAL PHILOSOPHY. By F. G. EDWARDS. Published by J. and A. Churchill, London. Pp. xii and 100. Price 3s. 6d.

By a space representation of the forms of atoms, the author seeks to explain their properties. He assumes that all matter is built up of tetrahedra: ether is supposed to consist of single tetrahedra, hydrogen of two tetrahedra joined together, and the other elements of a number of tetrahedra approximately twice the number expressing their atomic weight.

The mode of grouping the tetrahedra adopted gives a more or less well-marked periodic recurrence of similar forms with sunk or raised facets; the sunk facets predominating in the acidic elements, and the raised facets in the metallic atoms. The theory of molecules is rejected, and compounds are supposed to consist of atomic groupings, in which the metallic atoms with their raised facets vibrate to and fro between the sunk facets of the acidic atoms.

The theory is attractive, and will doubtless be accepted as the one and only solution of the laws of Nature by those who are able to reconcile the few seemingly adverse facts with the author's views. It is not strikingly obvious how the single tetrahedra composing the ether can be imponderable, despite the author's explanation, while the tetrahedra when grouped are ponderable. Many people will refuse to admit that the atomic weights of oxygen, chlorine, iodine and cadmium, generally accepted, are incorrect to about 1 per cent. of their value; others may fail to see any reason for the distortion of the tetrahedra, which occurs in all elements except hydrogen; and the sceptical may even ask whether the periodicity is not the result of choice of groupings rather than a natural sequence.

The work undoubtedly opens up a new vista in the domain of science, and the reader who masters the author's theory will not only broaden his mind, but will appreciate the great labour involved in the elaboration of the conclusions.

H. D. R.